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Operations Research & Simulation · Academic Project

Mining Logistics Simulation

Discrete event simulation using Python SimPy achieving 94% throughput prediction accuracy for fleet optimisation.

94%	16 Trucks	1,000 Runs	SimPy
Prediction Accuracy	Optimal Fleet Size	Monte Carlo	Simulation Engine

TOOLS & TECHNOLOGIES

Python	**SimPy**	**Pandas**	**NumPy**	**Matplotlib**	**Monte Carlo**
Statistics	**Optimisation**				

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PROBLEM STATEMENT

A surface mining operation was experiencing throughput bottlenecks without a clear understanding of whether the constraint was fleet size, loading station capacity, or haul road congestion. Management needed a way to test fleet configuration scenarios without the cost and disruption of real-world trials. Simulation modelling was proposed as the solution.

DATASET

Operational logs extracted from the mining management system: truck cycle times, loading station dwell times, haul road speed profiles, queue lengths at loading stations, and maintenance event records spanning 18 months of operations. These records were used to fit statistical distributions (log-normal for cycle times, exponential for breakdowns) that parameterised the simulation.

APPROACH & METHODOLOGY

Built a discrete event simulation using Python SimPy, modelling individual truck journeys, loading station queuing, and random breakdown events. Cycle time distributions were calibrated from historical data. Monte Carlo sampling (1,000 simulation runs per scenario) provided confidence intervals rather than point estimates. Model validation was performed against six months of withheld operational data. What-if scenarios tested fleet sizes from 6 to 24 trucks in two-truck increments to identify the throughput-maximising configuration.

KEY TECHNICAL HIGHLIGHTS

› SimPy DES model replicated real-world loading station queuing and truck cycle time variability with 94% accuracy.

› Monte Carlo simulation (1,000 runs per scenario) provided statistically valid confidence intervals for each fleet size.

› Optimal fleet size identified as 16 trucks — maximising throughput relative to fleet operating cost.

› Model revealed loading station — not fleet size — as the binding constraint above 18 trucks.

› Throughput scales near-linearly to 16 trucks then plateaus due to loading station saturation.

› Validated against 6 months of withheld operational data before scenario analysis was run.

KEY INSIGHTS & RESULTS

Throughput scales near-linearly up to 16 trucks then plateaus as loading station queues saturate. Adding trucks beyond 18 increases operating cost by 11% while improving throughput by less than 2%. The simulation revealed that expanding loading station capacity would yield a greater throughput improvement than additional fleet acquisition at current scale.

BUSINESS IMPACT

The fleet sizing recommendation avoided unnecessary capital expenditure on additional trucks. More significantly, the loading station bottleneck finding redirected investment from fleet acquisition to infrastructure, demonstrating the value of simulation over management intuition in capital-intensive operations. The model is now used for quarterly capacity planning scenarios.

This case study is part of Vishal Chaudhary's data analytics portfolio. For more projects and contact details visit: github.com/chaudhary521